The Past Earth's Rotation

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Summary. We have proposed a model to obtain the length of the day and month at any geologic time. The day is found to increase by 0.002 sec/century since the seventeenth century. The lengthening of the day is attributed entirely to the increasing gravitational constant (G) with time that manifested its self in tidal forces. The data obtained are consistent with those found from Palaeontology. The length of the day 4500 million years ago was 6 hours and the synodic month was 56.26 present epoch days.

1. INTRODUCTION

There exist certain large dimensionless ratios that may be formed from the fundamental constants of atomic physics and cosmology. In his large number hypothesis (LNH) Dirac proposed that these ratios are interrelated and are simple functions of cosmic time t. Thus the gravitational constant G, when measured in units of atomic time, varies as t^{-1}. The geophysical and palaeontolgical data ruled out this variation (Blake, 1978). This is manifested in the past number of days in a year and the length of the day derived from biological growth rhythms preserved in the fossil records investigated by Wells (1963). Based on different grounds, we have proposed a different temporal variation for G viz. $G \sim t^{(2n-1)/(1-n)}$ where $1/2 < n < 1$ is a constant related to viscosity. We emphasize that any changes in the Earth-Moon-Sun system are entirely due to gravitational effects that resulted from changes in G. Thus the 'effective' G embodies all these effects. For instance, the increase of the length of the day is generally attributed to tidal effects by the Moon on the Earth. Some scientists in celestial mechanics believed that lunar tides are generally responsible for the tectonic movement of the crust. In our present approach this variation is due to the increasing gravity that leads to change the tidal effects. It is therefore important to associate the time parameter when recording any information about the Earth. As G changes the following parameters of the Earth: Radius (R), Number of days in a year (Y), Length of the day (D), Earth temperature (T), and Moment of Inertia (I), will change. In this note we will be mainly concerned with changes in Y and D and their corresponding magnitudes.

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2- THE MODEL

Applying the Kepler's 2nd and 3rd laws of motion to the Earth-Moon system, neglecting the orbit eccentricity, one obtains

$$G^2[(M+m)^2m^3]T = 2\pi L^3 \quad , \quad G[(M+m)m^2]r = L^2 \tag{1}$$

and

$$G^2[(M+M_s)^2M^3]Y = 2\pi N^3 \quad , \quad G[(M+M_s)M^2]R = N^2 \tag{2}$$

for the Earth-Sun system, where m, M and M_s are the masses of the Moon, Earth and Sun respectively; L and N are their orbital angular momenta; R and r are the distance between Moon-Earth and Earth-Sun, respectively; Y and T are the length of the year and the sidereal month, respectively. The synodic month (T^s) is related to the sidereal month by the relation $T^s = T(1-T/Y)^{-1}$. While the lunar tidal friction resulted in angular momentum being transferred from the Earth's rotation about its axis to the orbital angular momentum of the Moon, the orbital angular momentum of the Earth around the Sun is nearly constant. From equation (1) and (2), one can write,

$$\frac{Y}{Y_0}\frac{T_0}{T} = (\frac{L}{L_0})^3 , \tag{3}$$

a relation that is valid at any geologic time (t). To fit the results obtained by Wells, one would require the gravitational constant to vary as $G \sim t^{1.3}$ and the present age of the universe (t_0) to be 11×10^9 year. Similarly, to fit the data obtained by Runcorn for the ratio $\frac{L}{L_0} = 1.016 \pm 0.003$ for the Devonian, one requires L to vary as $L \sim t^{0.43}$. Thus one can write the time dependent (evolution) of the above quantities as

$$G = G_0(\frac{t-t_0}{t_0})^{1.3} \ , \ Y = Y_0(\frac{t-t_0}{t_0})^{-2.6} \ , \tag{4}$$

$$D = D_0(\frac{t-t_0}{t_0})^{2.6} \ , \ L = L_0(\frac{t-t_0}{t_0})^{0.43} \ , \ T = T_0(\frac{t-t_0}{t_0})^{-1.3} \tag{5}$$

(in this note the subscript '0' denotes the present value of the quantity). Table 1 shows Wells's fossil data for the length of the year in the past and Table 2 shows our results. In fact, the year is the same as before but the length of the day was shorter than now. Sonett *et al.* (1996) have shown that the length of the day 900 m.y ago was 19.2 hrs and the year contained 456 days. This result is indeed what we obtain for that era. Recently, Williams (1997) has found the length of the day for the Precambrian from tidal rhythmite palaeotidal values. We would like to comment that the values he quoted belong to different eras in our model (see Table 3). Ksanfomality (1997) has shown that according to the principle of isochronism all planets had an initial period of rotation between 6-8 hrs. However, our model gives a value of 6.1 hrs. Berry and Baker (1968) have suggested that laminae, ridges and troughs, and bands on present day and Cretaceous bivalve shells are growth increments of the day and month, respectively. By counting the number of ridges and troughs they therefore find that the number of days in the month in the late Cretaceous was 29.65±0.18 and the year contained 370.3 days. Extrapolating the astronomically determined lengthening of the day since the seventeenth century leads to 371 days. As the Earth rotational velocity changes the Earth will adjust its self to maintain its equilibrium (shape) that is compatible with the new

situation. In doing so, the Earth should have experienced several geologic activities. Accordingly, one would expect that the tectonic movements have its root in these rotational velocity changes.

3- CONCLUSION

We have proposed a model for the variation of length of the day and month based on the idea of a variable gravitational constant. This variation can be traced back over the whole history of the Earth. All perturbations resulting from gravitational effects are included in the coupling constant G. The change in the Earth's parameters can be attributed to the effect of changing gravity with time in the manner shown in this note. The influence of gravity on the growth of these corals (biological system) is thus manifested in tidal effects that change the length of the day and month. These data can be inverted and used as a geological calendar. The data we have obtained for the length of the day and month should be checked against palaeodata that can be obtained from different disciplines. We have in this note suggested the temporal behavior of the Earth's parameters which is consistent with the hitherto known data. Further investigations are going on in this line.

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Table 1: Data obtained from *fossil corals and radiometric time*

Time (million years before present)	65	136	180	230	280	345	405	500	600
solar days/year	371	377	381	385	390	396	402	412	424

Table 2: Data obtained from the *principle of increasing gravity*

Time (million years before present)	Modern	65	136	180	230	280	345	405	500
solar days/synodic month	29.53	29.74	29.97	30.12	30.28	30.45	30.78	30.89	31.22
solar days/sidereal month	27.32	27.53	27.77	27.91	28.08	28.25	28.48	28.69	29.02
synodic month/year	12.37	12.47	12.59	12.66	12.74	12.82	12.93	13.04	13.20
sidereal month/year	13.37	13.47	13.59	13.66	13.74	13.82	13.93	14.04	14.20
solar days/year	365.24	370.9	377.2	381.2	385.9	390.6	396.8	402.6	412.2
length of solar day (hr)	24	23.6	23.2	23.0	22.7	22.4	22.1	21.7	21.3

Time (million years before present	600	900	1000	1200	1400	2000	3000	3500	4500
solar days/synodic month	31.58	32.72	33.11	33.93	34.79	37.63	43.48	47.09	56.26
solar days/sidereal month	29.39	30.53	30.92	31.75	32.61	35.46	41.33	44.90	54.14
synodic month/year	13.38	13.94	14.13	14.54	14.96	16.35	19.23	20.99	25.49
sidereal month/year	14.38	14.94	15.13	15.54	15.96	17.35	20.23	21.99	26.49
solar days/year	422.6	456	467.9	493.2	520.3	615.4	835.9	988.6	1434
length of solar day (hr)	20.7	19.2	18.7	17.7	16.8	14.2	10.5	8.8	6.1

Table 3: Williams's data (W) in comparison with our corresponding data (A)

Time (million years before present)	620 W	900 W	900 W	2500 W	435 A	566 A	1100 A	960 A
solar days/synodic month	30.5±0.5	31.1	33.0±0.4	32.1±1.6	30.99	31.46	33.52	32.95
solar days/sidereal month	28.3±0.5	28.9	30.9±0.5	30.0±1.8	28.79	29.26	31.33	30.76
synodic month/year	13.1±0.1	13.47	14.6±0.3	14.5±0.5	13.09	13.32	14.33	14.05
sidereal month/year	14.1±0.1	14.47	15.6±0.3	15.5±0.5	14.09	14.32	15.33	15.05
solar days/year	400±7	419	481±4	465±16	405.6	419	480.3	463.1
length of solar day (hr)	21.9±0.4	20.9	18.2±0.2	18.9±0.7	21.6	20.9	18.2	18.93